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Inventor(s): Ko YOSHIDA, Tsutomu SHIGA, and Shigenobu NAKAMURA

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Sir:

The undersigned, of the below address, hereby states that he/she well knows both the English and Japanese languages, and that the attached is an accurate translation into the English language of the above-identified application, which was/is being filed in the aforesaid foreign language.

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Applicant(s):	DENSO CORPORATION

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[Title of Invention] ROTARY ELECTRIC MACHINE WITH STATOR ELASTIC SUPPORT STRUCTURE
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[Name of the Document] SPECIFICATION

[Title of the Invention] ROTARY ELECTRIC MACHINE WITH STATOR ELASTIC SUPPORT STRUCTURE

[Claimed Scope for Patent]

[Claim 1] A rotary electric machine with a stator elastic support structure comprising:

a frame;

a stator core supported in the frame;

a stator winding inserted into slots of the stator core;

a rotor disposed opposite to the stator core to be rotatable;

a cooling fan for blowing air toward both coil ends of the stator winding; and

an elastic member disposed between the stator core and the frame, wherein:

the stator winding includes a plurality of U-shaped conductor segments each having a pair of leg parts to be inserted into the slots from one end side of the stator core, top ends of the leg parts protruding from the other end side thereof, and adjacent two top ends thereof being connected to each other; and

the conductor segments are arranged to have a predetermined clearance between adjacent two thereof at the both coil ends, into which air blown by the cooling fan flows.

[Claim 2] The rotary electric machine with the stator elastic support structure, according to claim 1, wherein:

an outer peripheral surface of the elastic member press-contacts an inner peripheral surface of the frame; and

an inner peripheral surface of the elastic member press-contacts an entire outer peripheral surface of the stator core.

[Claim 3] The rotary electric machine with the stator elastic support structure, according to any one of claims 1 and 2, wherein the elastic member has an elastic portion which is integrally formed by an elastic material between an outside cylindrical metal portion and an inside cylindrical metal portion.

[Claim 4] The rotary electric machine with the stator elastic support structure, according to claim 1, wherein:

the frame includes front and rear frame parts to be fastened in an axial direction while press-contacting outer peripheral edge surfaces of the stator core through the elastic member.

[Claim 5] The rotary electric machine with the stator elastic support structure, according to claim 4, wherein:

the elastic member includes front and rear ring elastic parts each having a L-shaped cross-section in the axial direction;

the front ring elastic part is inserted between a front edge surface and an outer peripheral surface of the stator core, and an edge surface and an inner peripheral surface of the front frame part; and

the rear ring elastic part is inserted between a rear edge surface and an outer peripheral surface of the stator core, and an edge surface and an inner peripheral surface of the rear frame part.

[Claim 6] The rotary electric machine with the stator

elastic support structure, according to claim 4, wherein:

the stator core includes both outer peripheral edge parts each having a ring step part;

the elastic member includes front and rear ring elastic parts each having a L-shaped cross-section in the axial direction;

the front ring elastic part is inserted between the step part of the stator core and an end surface and an inner peripheral surface of the front frame part; and

the rear ring elastic part is inserted between the step part of the stator core and an end surface and an inner peripheral surface of the rear frame part.

[Claim 7] The rotary electric machine with the stator elastic support structure, according to any one of claims 5, 6, wherein:

each of the front and rear ring elastic parts includes a ring elastic portion, an inner ring portion and an outer ring portion;

the ring elastic portion is made of an elastic material to have an L-shaped cross-section in the axial direction;

the ring elastic portion of the front ring elastic part is inserted between a front edge surface and an outer peripheral surface of the stator core and an edge surface and an inner peripheral surface of the front frame part;

the ring elastic portion of the rear ring elastic part is inserted between a rear edge surface and an outer peripheral surface of the stator core and an edge surface and an inner

peripheral surface of the rear frame part;

the inner ring portion made of a metal is inserted between the ring elastic portion and the stator core, and contacts the edge surface and the outer peripheral surface of the stator core;

the outer ring portion made of a metal is inserted between the ring elastic portion and any one of the front and rear frame parts, and contacts the edge surface and an inner peripheral surface of the any one; and

the elastic portion, the inner ring portion and the outer ring portion are integrated.

[Claim 8] The rotary electric machine with the stator elastic support structure, according to claim 4, wherein:

the elastic member includes front and rear elastic parts each having a L-shaped cross-section in the axial direction;

the front elastic part is inserted between any one of a step portion and both surfaces of a front edge surface and an outer peripheral surface of the stator core and an edge surface and an inner peripheral surface of the front frame part;

the rear elastic part is inserted between any one of a step portion and both surfaces of a rear edge surface and the outer peripheral surface of the stator core and an edge surface and an inner peripheral surface of the rear frame part; and

each of the front and rear elastic parts is composed of a plurality of unit elastic members, each having an approximately circular-arc shape, which are arranged in a circular direction while separated from each other by a predetermined dimension.

[Claim 9] The rotary electric machine with the stator

elastic support structure, according to any one of claims 4-8, wherein a middle part of the outer peripheral surface of the stator core in the axial direction is expose to an outside.

[Claim 10] The rotary electric machine with the stator elastic support structure, according to any one of claims 4-8, wherein the rear edge surface of the front frame part contacts the front edge surface of the rear frame part at a radial outside of the stator core.

[Claim 11] The rotary electric machine according to claim 1, wherein:

an inner peripheral surface of the frame has plural frame slots extending in an axial direction of the rotor at positions opposite to the stator core; and

the elastic member includes plural elastic parts which are inserted into the frame slots to form a part of the inner peripheral surface of the frame.

[Claim 12] A rotary electric machine with a stator elastic support structure, comprising:

a frame;

a stator core supported in the frame;

a stator winding inserted into slots of the stator core;

a cooling liquid passage in which cooling liquid flows toward the stator core, the cooling liquid passage being provided in the frame; and

an elastic member disposed between the stator core and the frame, the elastic member contacting the cooling liquid wherein:

the stator winding includes a plurality of U-shaped

conductor segments each having a pair of leg parts to be inserted into the slots from one end side of the stator core, top ends of leg parts protruding from the other end side thereof, and adjacent two top ends thereof being connected to each other; and

the conductor segments are arranged to have a predetermined clearance between adjacent two thereof at the both coil ends, into which air blown by a cooling fan flows.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a vehicle rotary electric machine which effectively reduces noise.

[0002]

[Prior Art]

In a rotary electric machine proposed in JP-B2-5-50217 by the present applicant, an elastic member is inserted between a stator core and a frame for reducing a magnetic noise. Hereinafter, this rotary electric machine is referred to as "rotary electric machine with stator elastic support structure". The elastic member has a structure where a rubber material is inserted between an outer metal cylinder and an inner metal cylinder.

[0003]

In a rotary electric machine described in USP 5629575, a shock absorbing member is inserted between a stator core and a frame so that an arrangement position of the stator core can be

readily set.

[0004]

In a rotary electric machine with stator elastic support structure described in JP-B2-2927288 by the present applicant, each of U-shaped conductor segments is inserted into a pair of slots. Top parts of conductor segments, projecting from the slots, are sequentially connected to form a stator winding (hereinafter, referred to as "stator winding with U-shaped-conductor sequential connection structure").

[0005]

[Problem to be Solved]

In recent years, it has been requested more and more to reduce a vehicle noise, and this request has been being realized. Therefore, a magnetic noise generated in a rotary electric machine has become conspicuous, and it is requested to reduce the magnetic noise. If the rotary electric machine is entirely covered by a noise insulation case, the magnetic noise can be reduced. However, this covered rotary electric machine cannot be actually used for a vehicle for troubles such as its mounting space, its weight increase and its cooling performance reduction.

[0006]

The above rotary electric machine with stator elastic support structure, having no above trouble, was expected to be actually used for a vehicle. However, according to studies performed by the present inventors, it has been found that the rotary electric machine with stator elastic support structure is difficult to be realized for a vehicle for the following reason.

That is, in the rotary electric machine with stator elastic support structure, it is difficult to radiate heat generated by a stator winding and a stator core, through a frame. Accordingly, temperature of the stator winding is increased, and an insulation film or an elastic member (especially, rubber) is readily heat-deteriorated. As a result, the stator winding is grounded or short-circuited, and a reduction effect for the magnetic noise is reduced. Naturally, a heat generation amount of the stator winding and the stator core can be reduced by enlarging the both. However, since a size and weight of the rotary electric machine are increased, the rotary electric machine cannot be actually used for a vehicle. It is also considered that temperature of the stator winding and the stator core is reduced by increasing a cooling air amount by increasing an air blowing amount of a fan. However, a sound noise of the fan is increased, and operational efficiency of the rotary electric machine is reduced, so that this consideration cannot be actually used.

[0007]

Eventually, according to an prior art, it is difficult to reduce magnetic noise of a vehicle rotary electric machine where it is requested to reduce its size and its weight.

[0008]

The present invention has been made in view of the above problems, and an object of the present invention is to provide a rotary electric machine with a stator elastic support structure, which reduces magnetic noise while preventing heat

deterioration of an elastic member or an insulator film.

[0009]

[Means of Solving the Problem]

In a rotary electric machine with stator elastic support structure defined in claim 1, a stator coil with U-shaped-conductor sequential connection structure is used as a stator winding, and conductor segments are arranged to be separated from each other by a clearance at both coil ends of the stator winding. These clearances are used as an air passage for cooling air blown by a cooling fan. Further, since each conductor segment has a large radial sectional area, its heat transfer performance is high in an axial direction. Therefore, a temperature of the stator winding can be markedly reduced, thereby reducing heat deterioration of an elastic member due to reduction of heat radiation performance of a stator core and the stator winding, to a level where a rotary electric machine can be actually used with no trouble. This heat deterioration reduction has been conventionally difficult to be solved in a rotary electric machine with a stator elastic support structure.

[0010]

According to a structure defined in claim 2, in the rotary electric machine with the stator elastic support structure according to claim 1, the elastic member is made to press-contact an entire outer peripheral surface of the stator core. Therefore, a temperature of a stator can be further reduced, and the stator can be stably supported.

[0011]

According to a structure defined in claim 3, in the rotary electric machine with the stator elastic support structure according to any one of claims 1 and 2, the elastic member is constructed by an elastic portion which is integrally made of elastic material between an outside cylindrical metal portion and an inside cylindrical metal portion. Therefore, the elastic member can be readily inserted between the stator core and the frame.

[0012]

Particularly, in the elastic member having this structure, the elastic member, heated and expanded within a temperature range where the elastic portion is permitted, can be fitted onto the cold stator core. Further, the cold elastic member can be fitted into the frame heated and expanded. That is, shrinkage fitting can be performed, thereby obtaining high connection strength between the elastic member and any one of the frame and the stator core.

[0013]

According to a structure defined in claim 4, in the rotary electric machine with the stator elastic support structure according to claim 1, the frame includes front and second frame parts to be fastened in an axial direction while press-contacting edge surfaces of the stator core through the elastic member. Therefore, the elastic member can be readily inserted between the stator core and the frame while the stator core can be strongly fixed to the frame. Further, a balance can be freely adjusted using a fastening level of a fastening member (generally, through

volt) between magnetic noise reduction effect of the elastic member and vibration-proof performance of the stator core with respect to the frame.

[0014]

According to a structure defined in claim 5, in the rotary electric machine with the stator elastic support structure according to claim 4, the elastic member includes front and rear ring elastic parts each having a L-shaped cross-section, and supports the stator core at front and rear peripheral edge surfaces and an outer peripheral surface. Therefore, the stator core can be stably supported in the frame in the axial and radial directions.

[0015]

Here, in the present specification, the L shape has a right angle or an approximately right angle, that is, an angle in a range of 75-105 degrees, between two sides (specifically, two surfaces).

[0016]

According to a structure defined in claim 6, in the rotary electric machine with the stator elastic support structure according to claim 4, the stator core includes both outer peripheral edge parts each having a ring step part, and the elastic member includes front and rear ring elastic parts each having a L-shaped cross-section in the axial direction. Further, the front ring elastic part is inserted between the step part of the stator core and an end surface and an inner peripheral surface of the front frame part, and the rear ring elastic part

is inserted between the step part of the stator core and an end surface and an inner peripheral surface of the rear frame part. Therefore, the stator core can be stably supported in the frame in the axial and radial directions.

[0017]

According to a structure defined in claim 7, in the rotary electric machine with the stator elastic support structure according to any one of claims 5, 6, each of the front and rear ring elastic parts includes a ring elastic portion, an inner ring portion and an outer ring portion. The ring elastic portion is inserted between the inner and outer ring portions. The inner ring portion made of a metal has an L-shaped cross-section in the axial direction, and contacts the stator core. The outer ring portion made of a metal has an L-shaped cross-section in the axial direction, and contacts the frame. Therefore, in the same manner as in claims 5, 6, the stator core can be stably supported in the frame in both of the axial and radial directions. Additionally, the elastic member can be shrinkage-fit to the stator core or the frame, thereby obtaining high connection strength therebetween. Here, steps may be generated in the stator core at the outer peripheral portion due to radial dimension variations and stacking dimension variations in each electromagnetic steel sheet. However, a soft connection portion cannot be damaged due to these steps at this fitting.

[0018]

According to a structure defined in claim 8, in the rotary electric machine with the stator elastic support structure

according to claim 4, each of front and rear elastic parts defined in claim 7 is composed of a plurality of unit elastic members each having an approximately circular-arc shape. Therefore, the same effect as in claim 7 can be obtained.

[0019]

According to a structure defined in claim 9, in the rotary electric machine with the stator elastic support structure according to any one of claims 4-8, a middle part of the outer peripheral surface of the stator core in the axial direction is expose to an outside. Therefore, the exposed outer peripheral surface of the stator core can be suitably cooled by cooling air and the like.

[0020]

According to a structure defined in claim 10, in the rotary electric machine with the stator elastic support structure according to any one of claims 4-8, the rear edge surface of the front frame part contacts the front edge surface of the rear frame part at a radial outside of the stator core. Therefore, rigidity of the rotary electric machine can be increased, and a shrink range of the elastic member can be accurately adjusted in the axial direction.

[0021]

According to a structure defined in claim 11, in the rotary electric machine with the stator elastic support structure according to claim 1, an inner peripheral surface of the frame has plural frame slots extending in an axial direction, and the elastic member is inserted into the frame slots. Therefore, at

power generation, the elastic member is heat-expanded to protrude to a side of the stator core or a radial inner side, thereby elastically supporting the stator core at the outer peripheral surface.

[0022]

According to a rotary electric machine with stator elastic support structure defined in claim 12, the elastic member disposed between the stator core and the frame contacts a cooling liquid, thereby preventing a heat deterioration of the elastic member while reducing magnetic vibration.

[0023]

Further, the elastic member can readily function as a seal member for the cooling liquid.

[0024]

[Embodiment of the Invention]

A rotary electric machine with a stator elastic support structure according to preferred embodiments of the present invention will be described with reference to the following examples.

[0025]

[First Embodiment]

Hereinafter, a vehicle alternating-current (AC) generator of the first embodiment, to which the present invention is applied, will be described with reference to appended drawings.

(Entire Structure)

FIG. 1 shows an entire structure of a vehicle AC generator used in this embodiment. This vehicle AC generator 1 includes

a rotor 2, a stator 3, a frame 4, a rectifier 5 and others.

[0026]

The rotor 2 includes a field coil 8 and a pair of pole cores 7 each having six claw poles. The field coil 8 is formed by cylindrically and coaxially winding insulated copper wire, and the pole cores 7 are fitted onto and fixed to a shaft 6. The field coil 8 is sandwiched between the pair of pole cores 7 and attached thereto. A cooling fan 11 is fixed by welding or the like to an end surface of the front pole core 7 so that cooling air sucked from a front side is blown out in a radial direction. Further, a cooling fan 12 is fixed by welding or the like to an end surface of the rear pole core 7 so that cooling air sucked from a rear side is blown out in the radial direction. Each pole core 7 is disposed so that its outer peripheral surface faces an inner peripheral surface of a stator core 32 by a predetermined clearance.

[0027]

The stator 3 includes a stator winding 31 and the stator core 32. The stator winding 31 is electrically insulated from the stator core 32 by resinous insulators 34 inserted into slots of the stator core 32. The stator winding 31 is formed of three phase windings connected to each other in a three-phase star type, and each phase winding is constructed by connecting plural conductor segments 33 in series in order as described later. Each of the conductor segments 33 is constructed mainly by two conductor segment parts 38, 39 each having a U shape as described later. A part of the stator winding 31 protrudes from both end

surfaces of the stator core 32 to form coil ends 36, 37.

[0028]

A peripheral wall of a frame 4 supports the stator core 32, and defines air-discharge windows 42, from which cooling air is discharged, opposite to the coil ends 36, 37 of the stator winding 31. An end wall of the frame 4 defines air-intake windows 41 from which cooling air is sucked.

[0029]

An outer peripheral surface of the stator 2 is fixed onto an inner peripheral surface of the frame 4 through an elastic member 50. In this example, the elastic member 50 is bonded onto the outer peripheral surface of the stator core 32. After the frame 4 is sufficiently thermal-expanded, the stator 2 to which the elastic member 50 is attached is inserted into the frame 4, and is assembled thereinto.

(Operation)

When torque is transmitted from an engine (not shown) to a pulley 20 via a belt and the like, the rotor 3 rotates in a prescribed direction. In this condition, a magnetic excitation voltage is applied to the field coil 8 of the rotor 3 from an outside, and the claw poles of the pole cores 7 are magnetized, so that three-phase AC voltage can be generated in the stator winding 31. As a result, a predetermined amount of direct current (DC) can be output from an output terminal of the rectifier 5.

(Description for the Stator Winding 31)

In FIG. 2, a cross-section of the stator 3 is shown by its

two slot parts in its radial direction. In FIG. 3, a schematic perspective view of a conductor segment 33 is shown.

[0030]

The stator core 32 has plural slots S for accommodating the plural phase windings. The insulators 34 electrically insulate the stator core 32 and the stator winding 31. In the present embodiment, the slots S are provided at 36 positions at the same intervals to accommodate the three-phase stator winding corresponding to pole numbers of the rotor 2. Within each slot S, even-numbered receiving parts C1, C2, C3, C4 (four receiving parts in this example) are provided in order from a radial inner side to a radius outside.

[0031]

The stator winding 31 constructed by connecting the conductor segments 33 can be divided into a linear slot conductor portion 35 to be accommodated in the slots S of the stator core 32, the first coil end 36 (curved side coil end) protruding from the slot conductor portion 35 outside the slot at the rear side, and the second coil end 37 (protrusion side coil end) protruding from the slot conductor portion 35 outside the slot at the front side.

[0032]

In each conductor segment 33, the conductor segment part 38 composed of plural flat wires is formed into a U shape with a large radial dimension, and the conductor segment part 39 composed of plural flat wires is formed into a U shape with a small radial dimension. In addition, an I-shaped conductor

segment part constructed by I-shaped wires is also used as a draining wire or a neutral-point connection wire.

[0033]

As shown in FIG. 3, the conductor segment part 38, having the U shape with the large radial dimension, includes an approximate U-shaped head portion 380 for constructing the first coil end 36 and a pair of leg portions 381, 382 extending from both ends of the head portion 380. The head portion 380 has a predetermined span between connection portions in a peripheral direction, at which the leg portions 381, 382 are connected to the head portion 380.

[0034]

The leg portion 381 includes a slot conductor portion 3811 accommodated in the slot S at the slot insertion position C1, and a top protrusion portion 3812 protruding to a front side from the slot conductor portion 3811. The top protrusion portion 3812 includes a connector 3813 at its top end.

[0035]

The leg portion 382 includes a slot conductor portion 3821 accommodated in the slot S at the slot insertion position C4, and a top protrusion portion 3822 protruding to a front side from the slot conductor portion 3821. The top protrusion portion 3822 includes a connector 3823 at its top end.

[0036]

Base ends (slot conductor portion side) of the top protrusion portions 3812, 3822 are separated from top ends thereof, respectively, by an approximate half dimension of the

peripheral direction span of the head portion 380.

[0037]

As shown in FIG. 3, the conductor segment part 39, having the U shape with the small radial dimension, includes an approximate U-shaped head portion 390 and a pair of leg portions 391, 392 extending from both ends of the head portion 390. The head portion 390 has a predetermined span between connection portions in a peripheral direction, at which the leg portions 391, 392 are connected to the head portion 390.

[0038]

The leg portion 391 includes a slot conductor portion 3911 accommodated in the slot S at the slot insertion position C2, and a top protrusion portion 3912 protruding to the front side from the slot conductor portion 3911. The top protrusion portion 3912 includes a connector 3913 at its top end.

[0039]

The leg portion 392 includes a slot conductor portion 3921 accommodated in the slot S at the slot insertion position C3, and a top protrusion portion 3922 protruding to a front side from the slot conductor portion 3921. The top protrusion portion 3922 includes a connector 3923 at its top end.

[0040]

Base ends (slot conductor portion side) of the top protrusion portions 3912, 3922 are separated from top ends thereof, respectively, by an approximate half dimension of the peripheral direction span of the head portion 390.

[0041]

The slot conductor portions 3811, 3821 of the pair of the leg portions 381, 382 of the conductor segment part 38, having the U shape with the large radial dimension, are respectively accommodated in different slots S separated from each other by a predetermined pole pitch. The slot conductor portions 3911, 3921 of the pair of the leg portions 391, 392 of the conductor segment part 39, having the U shape with the small radial dimension, are respectively accommodated in different slot S separated from each other by the predetermined pole pitch.

[0042]

As described above, the slot conductor portion 3811 of the leg portion 381 of the conductor segment part 38, having the U shape with the large radial dimension, is accommodated in the slot S at the shallowest slot insertion position C1. The slot conductor portion 3821 of the leg portion 382 of the conductor segment part 38, having the U shape with the large radial dimension, is accommodated in the slot S at the deepest slot insertion position C4.

[0043]

Similarly, the slot conductor portion 3911 of the leg portion 391 of the conductor segment part 39, having the U shape with the small radial dimension, is accommodated in the slot S at the shallower slot insertion position C2 which is a second shallowest insertion position. The slot conductor portion 3921 of the leg portion 392 of the conductor segment part 39, having the U shape with the small radial dimension, is accommodated in the slot S at the deeper slot insertion position C3 which is a

third shallowest insertion position.

[0044]

Accordingly, in the first coil end 36 on the rear side, the head portion 380 of the conductor segment part 38, having the U shape with the large radial dimension, can be disposed to cover the head portion 390 of the conductor segment part 39 having the U shape with the small radial dimension. Therefore, both head portions 380, 390 can be prevented from interfering with each other.

[0045]

Specifically, in the first coil end 36 on the rear side, the head portion 380 is connected to the slot conductor portion 3811 of the leg portion 381 inserted into the slot insertion position C1, and the slot conductor portion 3821 of the leg portion 382 inserted into the slot insertion position C4. Further, the head portion 390 is connected to the slot conductor portion 3911 of the leg portion 391 inserted into the slot insertion position C2, and the slot conductor portion 3921 of the leg portion 392 inserted into the slot insertion position C3.

[0046]

Further, in the second coil end 37 on the front side, the top protrusion portion 3812 of the leg portion 381 of the U-shaped conductor segment part 38, at the slot insertion position C1, is connected to the adjacent top protrusion portion 3912 of the leg portion 391 of the U-shaped conductor segment part 39, at the slot insertion position C2, at top end sides of the top protrusion portions 3812, 3912. Similarly, the top protrusion

portion 3822 of the leg portion 382 of the U-shaped conductor segment part 38, at the slot insertion position C4, is connected to the adjacent top protrusion portion 3922 of the leg portion 392 of the conductor segment part 39, at the slot insertion position C3, at top end sides of the top protrusion portions 3822, 3922.

[0047]

That is, in the second coil end 37 on the front side, the slot conductor portion 3811 of the leg portion 381, inserted into the slot insertion position C1, is connected to the slot conductor portion 3911 of the leg portion 391, inserted into the slot insertion position C2. Further, the slot conductor portion 3821 of the leg portion 382, inserted into the slot insertion position C4, is connected to the slot conductor portion 3921 of the leg portion 392, inserted into the slot insertion position C3. Accordingly, each of the three phase windings of the stator winding 31 is formed. A part of the second coil end 37 on the front side is shown in FIG. 4.

[0048]

Here, a slot conductor portion constructing a drain wire of the stator winding 31 and the other slot conductor portion have shapes different from those of the U-shaped conductor segment parts 38, 39. That is, in the first coil end 36 on the rear side, a U-shaped conductor segment having a special shape is provided for connecting the slot conductor portions at the slot insertion positions C1, C4 and the slot conductor portions C2, C3.

[0049]

In such a kind of stator coil with U-shaped-conductor sequential connection structure, since its structure and its wiring shape are identical to those in the prior art, its further description is omitted. Further, since the three-phase stator coil can be formed into various shapes, the above stator coil with U-shaped-conductor sequential connection structure can be naturally formed into various shapes by connecting plural conductor segment parts in order. According to such a manner, the stator winding 31 is formed.

(Cooling operation for the Stator Winding 31)

In this example, the stator winding is cooled mainly by air-cooling the coil ends 36, 37.

[0050]

Further described, as shown in FIGS. 3, 4, the conductor segments 33 are arranged at the coil ends 36, 37 to have predetermined clearances, that is, cool air passages therebetween. Therefore, cooling air blown by the cooling fans 11, 12 passes through the clearances, and discharges readily outside.

[0051]

That is, in the coil ends 36, 37 of the above stator winding 31 with U-shaped-conductor sequential connection structure, cooling air can uniformly contact the surfaces of the conductor segments 33 to absorb heat from the conductor segments 33.

[0052]

The conductor segment 33 has a sectional area greatly larger

than that of round-shaped conductive wire of the conventional wiring-type stator coil. Therefore, the stator winding 31 can be readily assembled without a deformation. Accordingly, it can prevent the coil ends 36, 37 from being partially super-heated due to a closed air passage or a narrowed air passage.

[0053]

Further, because the conductor segment 33 has the large sectional area, heat generated by the slot conductor portion, that is, the slot receiving portion of the conductor segment 33 can be readily transmitted to the coil ends 36, 37 in an extending direction of the conductor segment 33. Further, electrical resistance of the stator winding 31 can be reduced, so that heat-generating amount thereof can be reduced. Accordingly, it can also prevent a super-heating from being generated in the slot conductor portion of the conductor segment 33.

(Reduction of the Magnetic Noise)

In this example, as shown in FIG. 1, the stator core 32 is supported in the frame 4 through the elastic member 50.

[0054]

The elastic member 50 is formed by a rubber material into a cylindrical shape. The elastic member 50 reduces a magnetic noise transmitted to the frame 4 from the stator core 32.

[0055]

In this example, heat generated by the stator winding 31 with U-shaped-conductor sequential connection structure or the stator core 32 is radiated to air which directly contacts the

stator winding 31 at the coil ends 36, 37. Further, the stator winding 31 with U-shaped-conductor sequential connection structure is constructed by the conductor segments 33 which are formed by flat wires, and is arranged to have approximate equal clearances (air passages) therebetween at the coil ends 36, 37 in the peripheral direction.

[0056]

Accordingly, the stator winding 31 with U-shaped-conductor sequential connection structure has cooled performance at the coil ends 36, 37 greatly higher than a conventional winding-type stator coil formed by winding a round-shaped conductive wire around the stator core 32, turn by turn. Further, heat transfer resistance from the slot conductor portions to the coil ends 36, 37 is small, and a temperature difference therebetween is also small.

[0057]

Accordingly, temperatures of the stator core 32 and the stator winding 31 adjacent thereto can be sufficiently reduced as compared with a rotary electric machine having a conventional winding-type stator coil. As a result, heat-deterioration of the elastic member 50 can be reduced to a usable range, and it is made possible for the first time to insert the elastic member 50 made of rubber as a main material between the stator core 32 and the frame of the rotary electric machine.

(First Modification)

In the above-described first example, the elastic member 50 is formed into the cylindrical shape to cover an entire outer

peripheral surface of the stator core 32. However, the elastic member 50 can be formed into a round shape or a shape having plural protrusions. In this case, a part of the outer peripheral surface of the stator core 32 can be opposite to the inner peripheral surface of the frame 4 through a gap without contacting the elastic member 50.

[0058] In this case, a window for introducing cooling air can be provided in the frame 4 facing the gap.

(Second Modification)

In this modification, as shown in FIGS. 5 and 6, a pair of elastic members 501, whose shape is different from the shape of the elastic member 50 in the first example, are disposed to be inserted between stator core 32 and the frame 4 instead of the elastic member 50. Further, an opening 43 is provided at a position facing the outer peripheral surface of the stator core 32.

[0059]

Wall parts 44, 45 extend in a peripheral direction. The wall part 44 is disposed between the discharge opening 42 at the front side and the opening 43, and the wall part 45 is disposed between the air openings 42 at the rear side and the opening 43. Each of the wall parts 44, 45 has a L-shaped cross section in an axial direction.

[0060]

Each of the elastic members 501 is formed by a rubber ring having a L-shaped cross section in the axial direction. The elastic members 501 are disposed between both outer peripheral

edge parts of the stator core 32 and both wall parts 44, 45, respectively.

[0061]

The elastic member 501 at the front side has two sides extending to a radial inner side and the rear side, respectively, and press-contacts the stator core 32 at the outer peripheral surface and the front outer peripheral edge parts. Further, the elastic member 501 press-contacts both surfaces of a step portion of the wall part 44 of the frame 4 at a rear opening edge, extending to a radial inner side and the rear side, respectively. The elastic member 501 at the rear side has two sides extending to a radial inner side and the front side, respectively, and press-contacts the stator core 32 at the outer peripheral surface and the rear outer peripheral edge parts. Further, the elastic member 501 press-contacts both surfaces of a step portion of the wall part 44 of the frame 4 at a front opening edge, extending to a radial inner side and the front side, respectively. The two elastic members 501 having the same shapes can be disposed reversely in the axial direction.

[0062]

According to such a manner, the elastic members 501 can reduce both of vibrations in the radial direction and in the axial direction, transmitted from the stator core 32 to the frame 4. In addition, the outer peripheral surface of the stator core 32 can be effectively cooled through the opening 43.

[0063]

In this example, it is preferable that the wall part 44 is

provided at a rear end of the front frame and the wall part 45 is provided at a front end of the rear frame. In this case, by fastening the front frame and the rear frame using a through bolt, the stator core 32 can be held between the front frame and the rear frame.

(Third Modification)

In this modification, as shown in FIGS. 7 and 8, it is different from the second modification that an elastic member 502 is used in place of the elastic member 501 in the second modification.

[0064]

Each of the elastic members 502 has an elastic portion 502c having a ring shape similar to that of the elastic member 501 in the second modification, and metal rings 502a, 502b integrated to both sides of the elastic portion 502c. Each of the metal rings 502a, 502b has L-shaped cross section in the axial direction.

[0065]

In this modification, because the elastic portion 502c is inserted between the metal rings 502a, 502b to be held therebetween in the elastic member, assembling variation of the stator core 32 can be reduced in its posture and its location. Therefore, the stator core 32 can be prevented from being shifted from the rotor 2. Accordingly, an air gap between the inner peripheral surface of the stator core 32 and the outer peripheral surface of the rotor 2 can be made uniform, so that a magnetic pulsation can be prevented from being unbalanced, and the

magnetic noise can be further reduced.

(Fourth Modification)

In this modification, as shown in FIG. 9, the shape of the frame 4 is changed so that a flat tube 8 is provided between the frame 4 and the stator core 32 while the elastic members 502 described in the third modification are used.

[0066]

Further described, the frame 4 includes a front frame 4a having a step-like rear opening end, and a rear frame 4b having a step-like front opening end. The step-like rear opening end of the front frame 4a and the step-like front opening end of the rear frame 4b are engaged with each other. A wall part 44' of the front frame 4a is located directly at the back of the discharge opening 42 at the front side, and contacts the metal ring 502a of the front elastic member 502 at the outer peripheral side. In the same manner, a wall part 45' of the rear frame 4b is located directly in front of the discharge opening at the rear side, and contacts the metal ring 502a of the rear elastic member 502 at the outer peripheral side.

[0067]

The flat tube 101, in which water 100 is enclosed, is formed by a thin aluminum pipe. The flat tube 101 contacts an outer peripheral surface of the stator core 32 and inner peripheral surfaces of the wall parts 44', 45', thereby performing heat transfer therebetween. Further, the stator core 32 is cooled by making water flow in the flat tube 101.

[0068]

According to this manner, the temperature of the stator core 32 can be further reduced, and the heat deterioration of the elastic portion 502c can be prevented.

(Fifth Modification)

In this modification, as shown in FIGS. 10 and 11, the elastic portion 502 shown in FIGS. 7, 8 is modified to an elastic portion 503 having a different shape while the shape of the stator core 32 is changed.

[0069]

Further described, the wall part 44 of the front frame 4a is located directly at the back of the discharge opening 42 at the front side, and includes a step portion 100 having an inner peripheral surface and a rear edge surface press-contacting the metal ring 503a of the front elastic member 503 at the outer peripheral side. Similarly, the wall part 45 of the rear frame 4b is located directly in front of the discharge opening at the rear side, and includes a step portion having an inner peripheral surface and a front edge surface press-contacting the metal ring 503a of the rear elastic member 503 at the outer peripheral side.

[0070]

The front elastic member 503 has two sides extending to a radial outer side and the front side, respectively, and press-contacts a step portion of the stator core 32 provided at its front outer-peripheral edge. Further, the front elastic member 503 press-contacts both surfaces of a step portion of the wall part 44 of the frame 4 at a rear opening edge, extending to a radial direction and the rear side, respectively. The rear

elastic member 503 has two sides extending to a radial outer side and the rear side, respectively, and press-contacts a step portion of the stator core 32 provided at its rear outer-peripheral edge. Further, the front rear member 503 press-contacts both surfaces of a step portion of the wall part 44 of the frame 4 at a front opening edge, extending to a radial direction and the front side, respectively. The two elastic members 503 having the same shapes can be disposed reversely in the axial direction.

[0071]

According to this manner, an arrangement position of the stator core 32 can be accurately determined, while the magnetic noise can be reduced and cooling performance of the stator core 32 can be ensured.

(Sixth Modification)

As shown in FIG. 12, this modification is different from the first example only in the view point where the elastic member 50 of the first example shown in FIG. 1 is changed to an elastic member 504 similarly having a cylindrical shape.

[0072]

The elastic member 504 includes an elastic portion 504c formed into a ring shape by a rubber ring, and metal cylindrical portions 504a, 504b each having an L-shaped cross-section. Therefore, assembling variation of the stator core 32 can be reduced in its posture and its location.

(Seventh Modification)

In this modification, the elastic portion 504c is made of

a rubber material where a powder of a heat-conductive material such as an aluminum powder or an aluminum short fiber is mixed.

[0073]

According to this manner, a resistance of heat-transmission in the radial direction of the elastic portion 504c can be reduced. Therefore, while heat deterioration of the elastic portion 504c can be restricted, the magnetic noise can be reduced.

(Eighth Modification)

In this modification, as shown in FIG. 13, an elastic member 502 having a ring shape shown in FIGS. 7, 8 is divided into plural circular-arc elastic pieces 505b each having a predetermined angle, as an elastic member. The plural circular-arc elastic pieces 505b are arranged in a circumferential direction at predetermined positions so that a predetermined space is provided between adjacent elastic pieces 505b in the circumferential direction.

[0074]

The elastic member 505 has the same effects as of the elastic member 502. Further, since the spaces between the elastic pieces 505a can be used as a cool air passage, the stator core 32 can be effectually cooled using the cool air passage.

[0075]

As in this manner, each of the elastic members described above can be divided into the necessary number of circular-arc elastic pieces, and these circular-arc pieces are arranged in a circumferential direction to form the elastic member.

(Ninth Modification)

In this modification, as shown in FIG. 14, plural slots 401 are provided in the inner peripheral surface of the frame 4 in its axial direction, for covering the outer peripheral surface of the stator core 32, and plural elastic members 504 are inserted into the slots 401.

[0076]

In FIG. 14, each of the slots 401 has an approximate semi-circular shape in cross section in a radial direction. Further, surfaces of the elastic members 504, exposed to an inner side in the radial direction, define the inner peripheral surface of the frame 4 together with an inner peripheral surface of the frame 4 without the slots 401. Here, the elastic members can slightly protrude from the inner peripheral surface of the frame 4.

[0077]

According to this manner, when electrical power is generated, the elastic members 504 are heat-expanded to protrude to the side of the stator core 32, that is, to the inner side in the radial direction. Therefore, the outer peripheral surface of the stator core 32 can be elastically supported by the elastic members 504 arranged in the peripheral direction with a predetermined pitch.

(Tenth Modification)

In this modification, as shown in FIG. 15, cooling water flows at a radial outer side of the elastic member 50.

[0078]

The elastic member 50 also exhibits a function of a seal

member for cooling water while reducing magnetic vibration from the stator core 32.

[0079]

Accordingly, heat-deterioration of the elastic member 50 can be restricted while cooling performance of the stator core 32 can be improved.

[0080]

In this example, the rotary electric machine may not be an open type using a cooling fan, but a seal type using sealed frames 4000, 4001. In this case, a frame strength can be improved, and the magnetic noise can be further reduced.

(Other Modification)

In the above-described embodiments, the elastic member is molded while the metal rings are integrated to the elastic member, and the metal ring contacting the outer peripheral surface of the stator core 32 is shrinkage-fit onto the stator core 32. Accordingly, the elastic member beforehand integrated to the stator core 32 can be simply assembled to a frame 4, so that assembling operation of a rotary electric machine can be made simple without reducing assembling accuracy and magnetic-noise reduction effect.

[Brief Description of the Drawing]

[FIG. 1] FIG. 1 is an axial sectional view showing a structure of a rotary electric machine with a stator elastic support structure according to an example of the present invention.

[FIG. 2] FIG. 2 is a radial sectional view showing a part of a stator shown in FIG. 1.

[FIG. 3] FIG. 3 is a perspective view showing a part of a stator winding shown in FIGS. 1, 2.

[FIG. 4] FIG. 4 is a perspective view showing a coil end of the stator winding at a front side, shown in FIG. 1.

[FIG. 5] FIG. 5 is an axial sectional view showing a part of a rotary electric machine with a stator elastic support structure according to a modification of the present invention.

[FIG. 6] FIG. 6 is a partial perspective view showing an elastic member shown in FIG. 5.

[FIG. 7] FIG. 7 is an axial sectional view showing a part of a rotary electric machine with a stator elastic support structure according to another modification of the present invention.

[FIG. 8] FIG. 8 is a partial perspective view showing an elastic member shown in FIG. 7.

[FIG. 9] FIG. 9 is an axial sectional view showing a part of a rotary electric machine with a stator elastic support structure according to another modification of the present invention.

[FIG. 10] FIG. 10 is an axial sectional view showing a part of a rotary electric machine with a stator elastic support structure according to another modification of the present invention.

[FIG. 11] FIG. 11 is a partial perspective view showing an elastic member shown in FIG. 10.

[FIG. 12] FIG. 12 is an axial sectional view showing a part of a rotary electric machine with a stator elastic support structure according to another modification of the present invention.

[FIG. 13] FIG. 13 is an axial sectional view showing a part of a rotary electric machine with a stator elastic support structure according to another modification of the present invention.

[FIG. 14] FIG. 14 is an axial sectional view showing a part of a rotary electric machine with a stator elastic support structure according to another modification of the present invention.

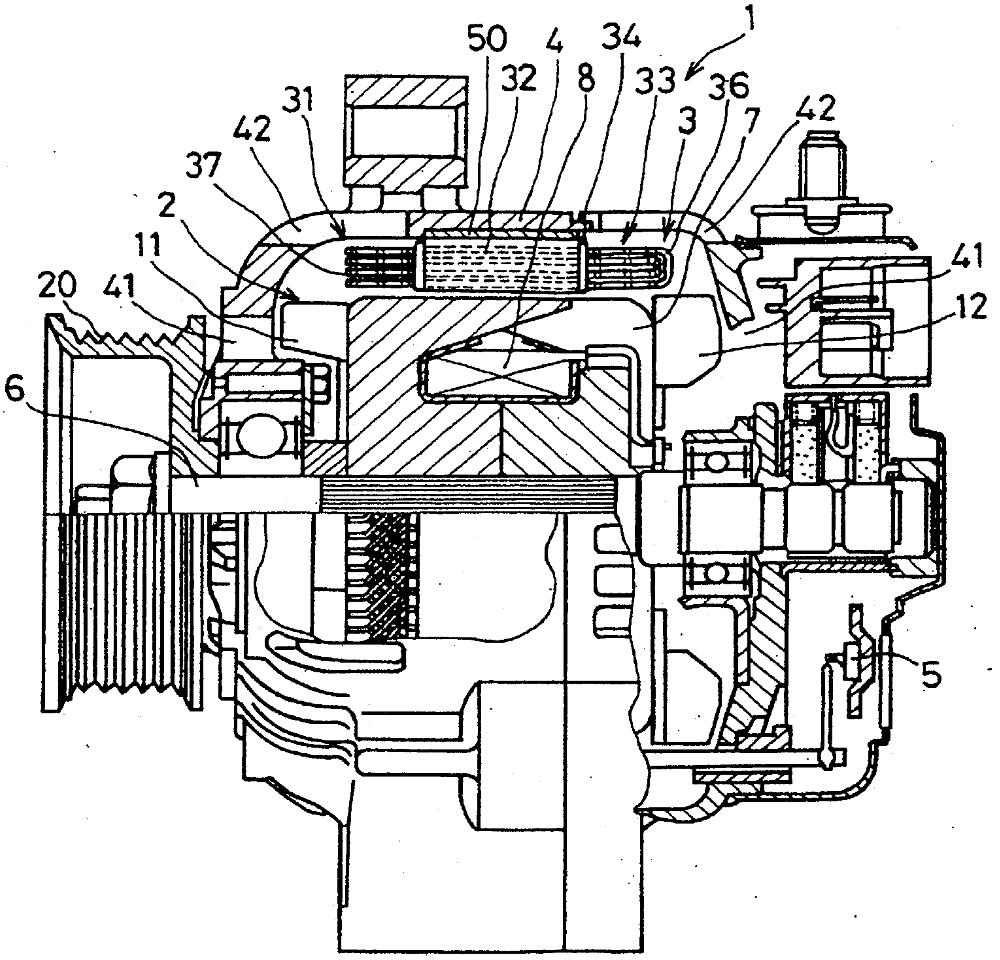
[FIG. 15] FIG. 15 is an axial sectional view showing a part of a rotary electric machine with a stator elastic support structure according to another modification of the present invention.

[Explanation of Numerals]

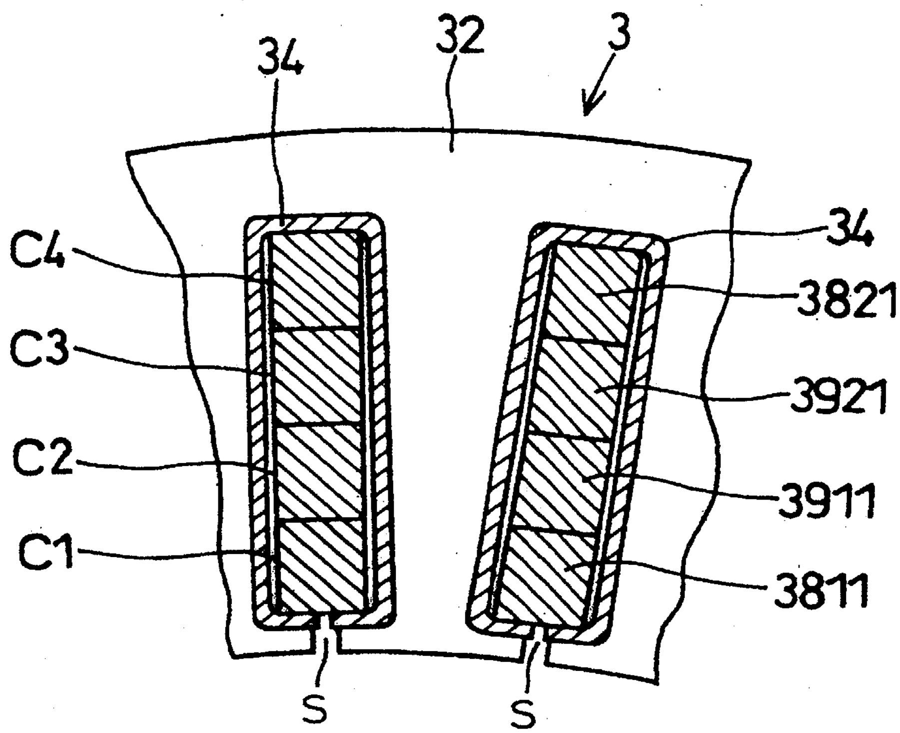
2 - a rotary, 3 - a stator, 4 - a frame, 11, 12 - a cooling fan, 31 - a stator winding, 32 - a stator core, 33 - a conductor segment, 36, 37 - a coil end, 50 - an elastic member, S - a slot, 502 - an elastic member (front elastic member, rear elastic member), 502a - a metal ring, 502b - a metal ring, 502c - an elastic portion, 44' - a wall part, 45' - a wall part, 100 - a step portion (step)

[Name of Document]
【書類名】　図面 Drawing

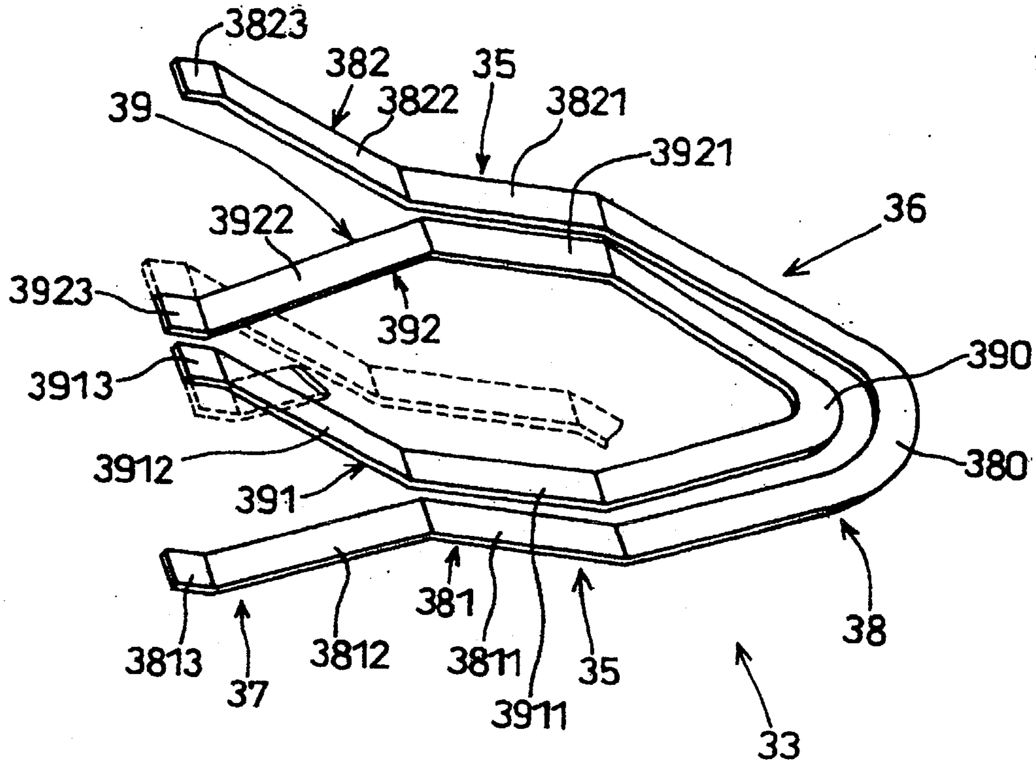
【図１】 [FIG.1]



【図２】　[FIG. 2]



【図３】　[FIG.3]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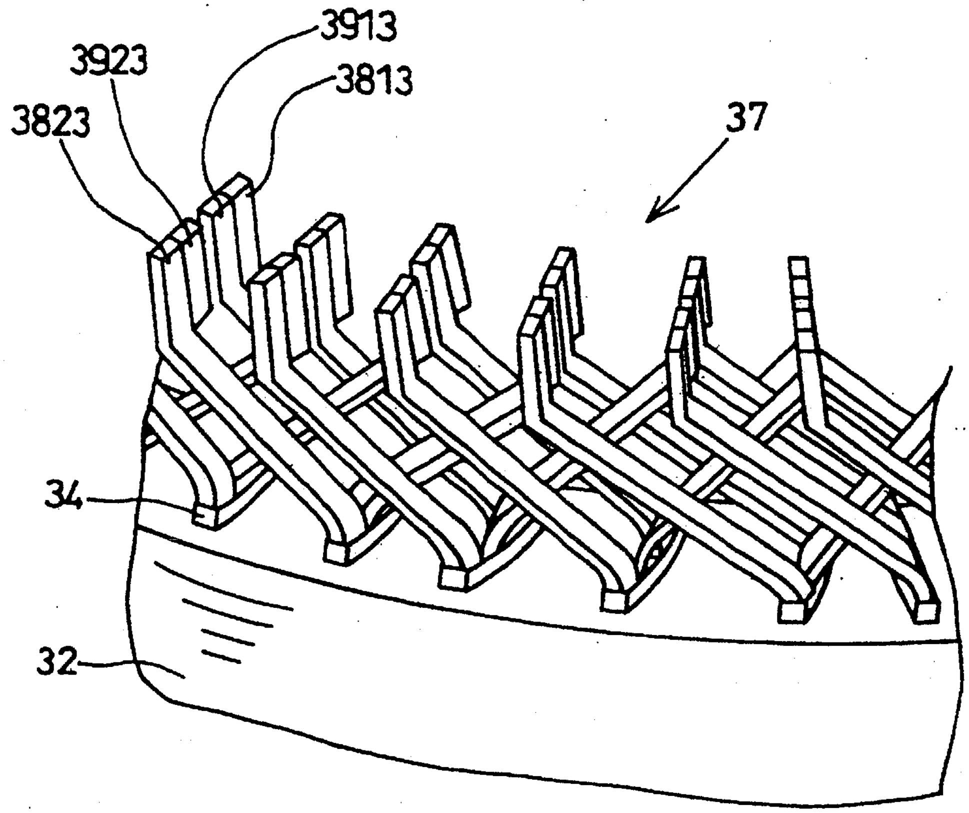
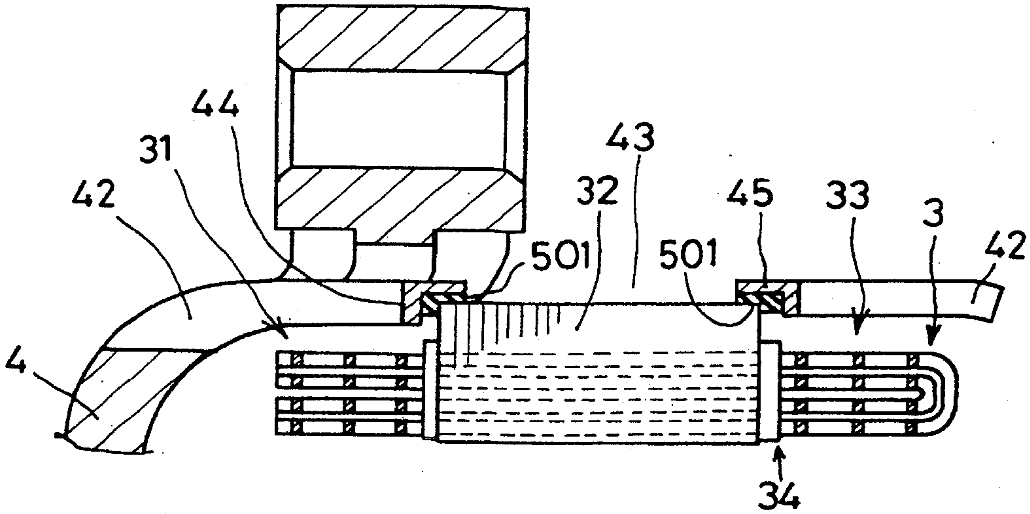
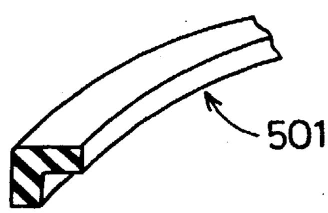
【図４】 [FIG.4]



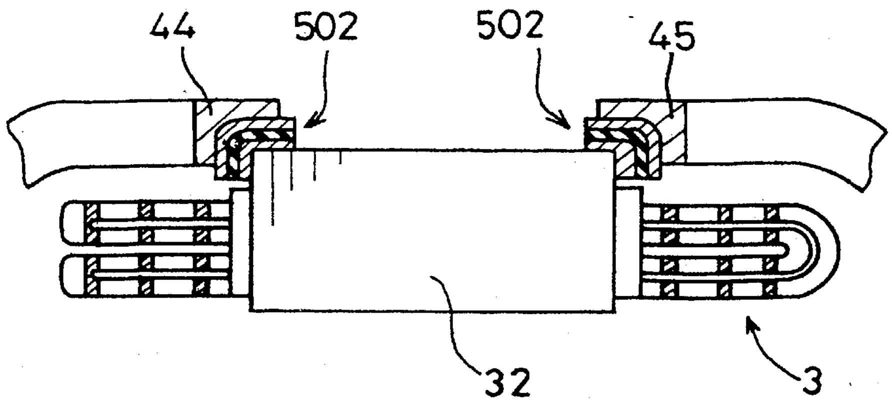
【図５】　[FIG. 5]



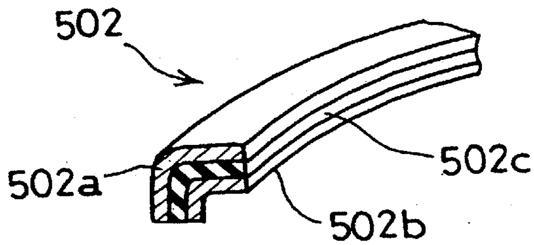
【図６】　[FIG. 6]



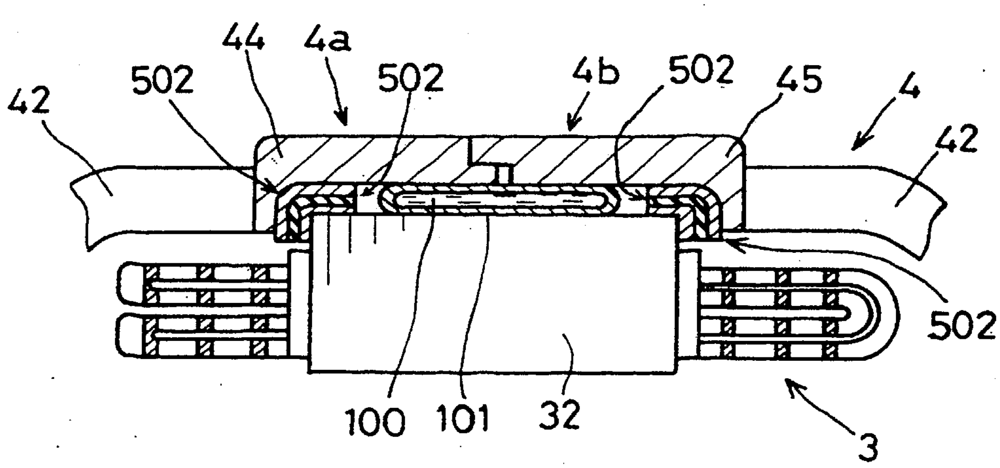
【図７】　[FIG. 7]



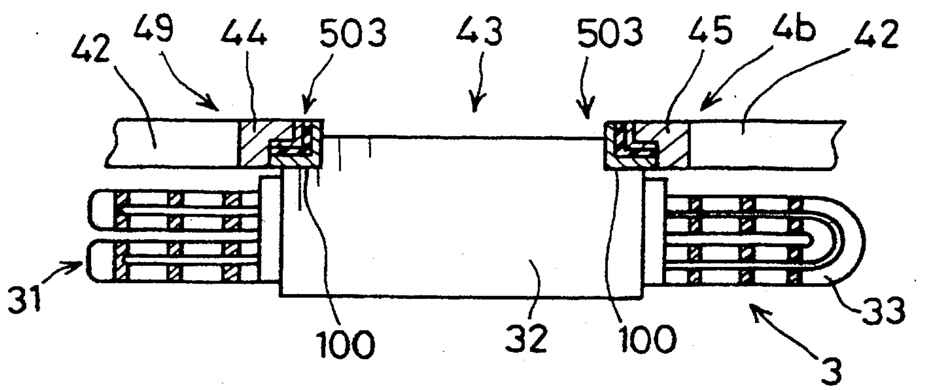
【図８】　[FIG. 8]



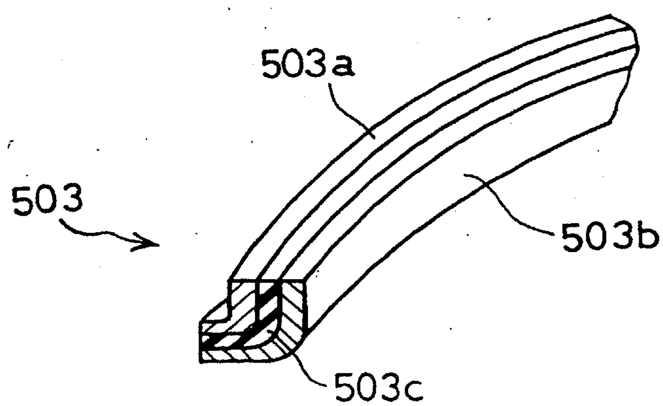
【図９】　[FIG. 9]



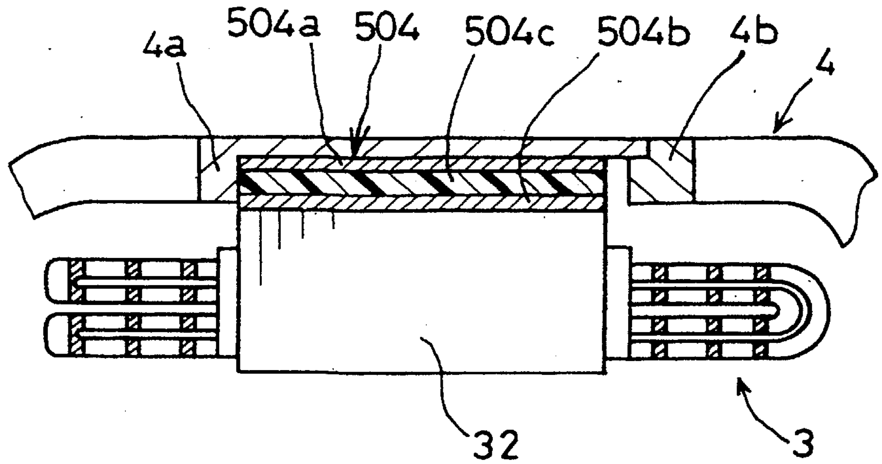
【図１０】 [FIG. 10]



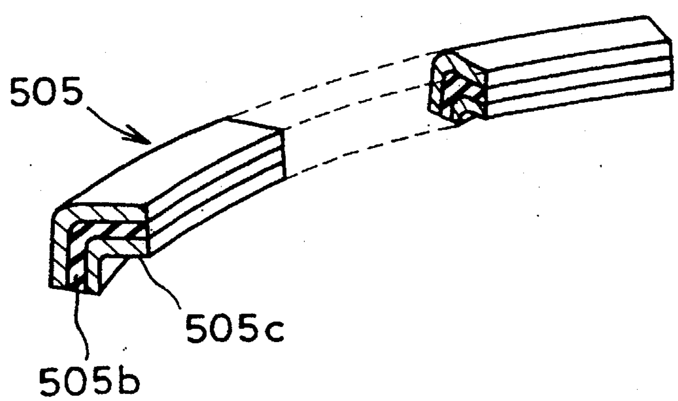
【図１１】 [FIG. 11]



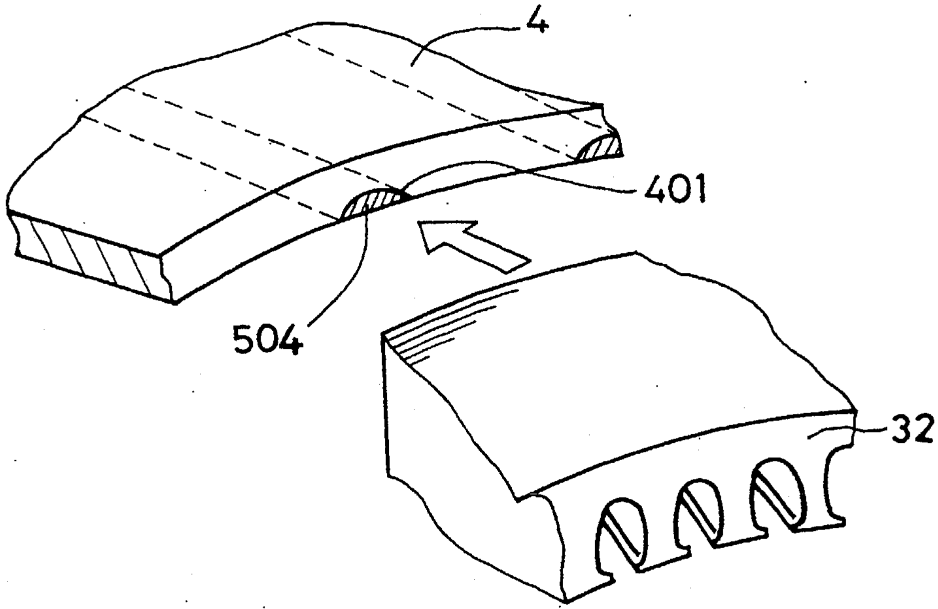
【図１２】 [FIG. 12]



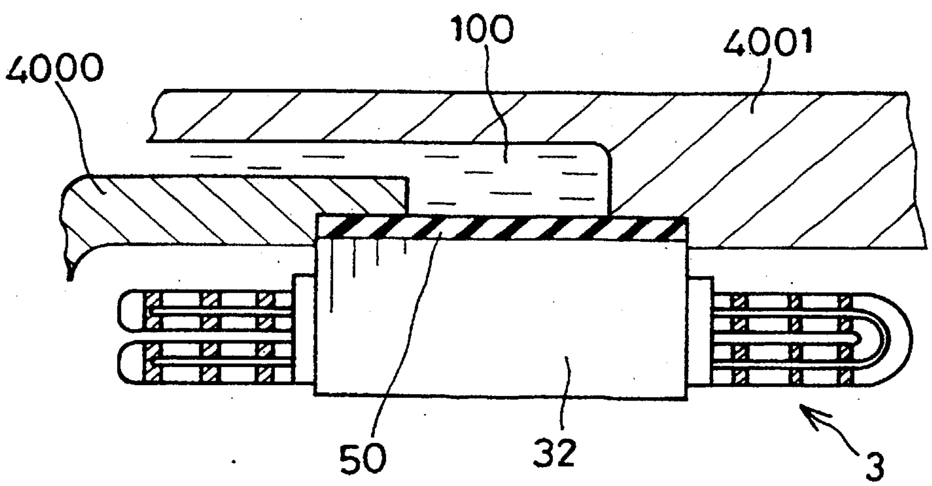
【図１３】 [FIG. 13]



【図１４】　[FIG. 14]



【図１５】　[FIG. 15]



[Name of the Document]

[Abstract]

[Object] An object of the present invention is to provide a rotary electric machine with a stator elastic support structure, which can reduce magnetic noise while preventing heat deterioration of an elastic member or an insulator film.

[Means for Solving problems] In a rotary electric machine with a stator elastic support structure, a stator winding with U-shaped-conductor sequential connection structure is used as a stator winding 31, and conductor segments 33 are arranged to have a predetermined clearance between adjacent two thereof at both coil ends of the stator winding 31. These clearances are used as an air passage for cooling air blown by a cooling fan. Further, since each conductor segment 33 has a large radial sectional area, its heat transfer performance is high in an axial direction. Therefore, a temperature of the stator winding 31 can be markedly reduced, thereby reducing heat deterioration of an elastic member 4 due to reduction of heat radiation performance of a stator core 32 and the stator winding 31, to a level where a rotary electric machine can be actually used with no trouble. This heat deterioration reduction has been conventionally difficult to be solved in a rotary electric machine with a stator elastic support structure.

[Selected Figure] FIG. 10